



Planetary Protection: On the Moon and Learning for Mars

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Overview

- **Planetary Protection (PP) Policies:**
 - What they are. How they Apply to Human Long Duration Missions
 - Recent changes in PP at COSPAR
- **Focus on Key Systems- Series of Workshops**
 - Contaminants, Pathways, Normal Ops & Off-Nominal Events
- **Understand Risks for Human Missions**
 - Forward Contamination Controls as needed
 - Protecting Astronauts
 - Back Contamination – Protect Earth upon Return
 - Recommendations, R&D Needs and Precursor Information
- **Lunar Experiences & Science—Feed Forward to Mars?**



What's Planetary Protection (PP)?

Like Environmental Protection for the Solar System

- Based on **Outer Space Treaty of 1967**(OST) and **COSPAR** Policies
- **Avoid Hazardous Cross Contamination** During Exploration ('hitchhiker' organisms)
 - ✓ **Protect Planets and Science**
 - ✓ **Control Forward and Back Contamination**
- All US Missions **Must Comply** With OST and PP Policies
- Requirements Depend on Target, Science & Probability for ET Life
- NASA Directives and Requirements Apply



Robotic Missions:

- ✓ **PP = Strict, Conservative, Not Optional or Add-on**
- ✓ **Long Lead Time for Plans, Designs, Technology & Operations**
(e.g. Mars Missions: Flybys, Orbiters, Landers, Penetrators etc.)

Human Missions Ditto... Exact Details TBD



How Do PP Regulations Apply To Missions?

PLANET PRIORITIES

		MISSION TYPE	MISSION CATEGORY	REQMTS.
A	Not of direct interest for understanding the process of chemical evolution. No protection of such planets is warranted (e.g., MOON , Most Asteroids)	Any	I	None
B	Of significant interest relative to the process of chemical evolution, but only a remote chance that contamination.... (e.g. Venus, Jupiter, Saturn, Uranus, Neptune, Pluto, KBOs, asteroids)	Any	II	PP Plan Documents
C	Of significant interest relative to the process of chemical evolution and/or the origin of life or for which...a significant chance of contamination which could jeopardize a future biological experiment. e.g. MARS , Europa, others TBD	Flyby, Orbiter	III	**
		Lander, Probe	IV	**
All	Any Solar System Body (All)	Earth-Return	V	Unrestricted MOON Restricted ** Mars

****** PP Plan, Documentation, Plus Trajectory Biasing, Cleanroom Assembly, Bioload Reduction Of Hardware, Orbital Lifetimes As Necessary



How Will PP Effect Human Lunar Missions?

Lunar Missions: No Significant PP Concerns

Forward Contamination Controls: Category II - Limited PP Reqmts.

Back Contamination Controls: Category V - Unrestricted Earth Return

Even So, Consider PP in Lunar Architecture Planning:

- ✓ Use Moon as Test Bed to Enable Future Mars Missions
- ✓ Help Guide the Designs, Equipment, Protocols, Operations for Long Duration Missions
 - ALS, EVA, EMC, Science Activities
- ✓ Avoid Pursuing Two Distinct, Expensive Technology Pathways

Draw from Apollo and Recent Workshops/Studies on PP and Mars Missions

Identified Science, Life Support, Environmental and Technology Issues

- NASA-ESA PP and Humans on Mars Workshop- Nordwijk, May 2005
- NASA LSH and PP Workshop- Houston, April 2005
- NASA Workshop PP Issues in Human Mars Exploration, Pingree Park, Summer 2001
- Also: MEPAG 2005 JPL - Precursor Info to Reduce Risks of Human Mars Missions
- Draft Protocol for Handling and Testing Mars Returned Samples, 2002

Three Important Foci to Consider:

- Risks to Target Planet
- Risks to Astronauts During Mission
- Risks to Earth

Moon vs. Mars

Biohazards & Risks Associated with Forward Contamination

Biohazard	Risk	Solution
Earth Microbes	Humans as Microbial 'Carriers' Assume Unavoidable	Minimize Contact with Mars; Mitigate by design and operations
	Spacecraft and Equipment deliver microbial contaminants	Clean/Bioburden Reduction Cleanroom Assembly Repair/Maintain/Decontaminate
	Sampling equipment and operations; Special concern for Subsurface	Strict cleanliness Like Robotics; Protocols for Repair/Maintain/Decontaminate
	Local vs. Widespread Contamination Different Risks and Standards By Zone; Risk Info from Precursor Robotic Science	<u>Classification Systems</u> Landing Area: ZMBR and Other Zones for Human Ops vs Science/Biology/Contamination Concerns Timing and Sequencing of Operations
Other Hazards	Dusts	Dispersal; Research on Dust and Microb. Survival; spread
	Food and Biological Waste Technologies (microbial hitchhikers; use of microbial treatment systems) ISRU, Other systems?	Controls TBD Solid & Liquid Wastes Contained Need Extremophile Research Avoid Environmental Disruption?
	EVA, Suits, Habitats (escape of microbes—ingress/egress; leakage; etc)	Design and Operations; Venting of all Gases Need to Inventory and /Understand Microbes (on people v. equipment.)
Organic Contaminants	Unavoidable organic materials as 'biomarkers'; False Positives	Need Understand via Inventory and research; Design to Minimize
For All Biohazards	Monitoring, Detection, Alarms, Controls Critical inside, outside and in mobile units; microbes& organics included in monitoring	Technology, sensors and methods TBD Inside and outside

Biohazards and Risks to Astronauts

Biohazard	Risk	Solution
M a r t i a n Biohazards	Physical Health/Safety (Chemical, Radiation, Desiccation etc.)	TBD: Modify Operations Medical Monitoring and Safeguards For Mars
M a r t i a n Microbes?	Astronauts Exposed To Martian Life/Dusts? (EVA's, Lab, Food, Etc)	Monitoring And Control; Decontamination; Separation Of Modules; Quarantine Capabilities
	Exposures Beyond Landing Area (Zones of Minimal biological risk- ZMBR- Verified)	<u>Classification System for Areas based on:</u> Biological/Science , Contam. Concerns Human Operation Zones Timing And Sequencing
	Special Concern For Subsurface And Unknown Areas During Sampling & Exploration	Need Human-Robotic Pairings; Strict Cleanliness Requirements Like Robotic Missions; Sterilization of Sampling Equipment Repair/Maintain/Decontaminate
	3 rd Ecology Concerns (Creation Of Hybrid Microenvironments?)	Special Attention On Waste Treatment Systems And Food Production; Monitoring of environments?

Biohazards and Risks: Back Contamination of **Earth**

Biohazard	Risk	Solution
Mars Replicating Microbes?	Impossible To Break Contact with Mars	Minimize Contact w/Mars Materials thru Ops and Equipment; Leave Wastes/ extra materials behind upon return?
	Uncertainty About Existence Or Extent Of Martian Life	Classification System “Safe” Zones; (ZMBR); Emphasis on ‘Special Regions’
	EVA, Suits, Rovers, Habitats Etc	New Technologies: minimize possibility of cross contamination w/ martian materials; Technologies for cleaning and decontamination
	Transfer Lab And Exploration Samples, Particularly From Uncleared Zones Or Subsurface	Strict Separation And Containment of pristine materials (Similar To Robotic Missions?)
	Potential For 3rd Ecology ?	Treatment and Waste Handling Systems designed to avoid Mixes Of Earth Microbes & Martian Materials
	Food Production, Water Treatment, Off-Nominal Events, and Misc. Systems, etc.	TBD: Liquid and solid Wastes Contained, Special planning for off nominal events (e.g.: Fire Suppression, Depressurization, Etc.) Shutdown/Unoccupied?
	What if Crew Exposed? On-going monitoring/detection/control	Medical Monitoring And Quarantine As Part Of Mission Architecture On Mars & Earth; PP info as part of alarm and control systems?
	PP Oversight	Designated PP Crew Member for PP; Human Factors Research



Relevant Findings on PP and Human Missions

- **Safeguarding Earth Is Highest Priority**
- **Must Assume Can't Have Entirely Enclosed Systems For Science And Activities**
- **People *Will* Contaminate And *Be* Contaminated**
 - How Limit Exposure? How Control Contaminants?
 - Forward And Back Contamination
- **PP *Will* Affect Design, Operations And Costs Of Life Support, Environmental And Scientific Systems**
 - Identify Contaminants And Pathways (Nominal)
 - Consider Off-Nominal Events Typical Of Systems
 - Derive Engineering Requirements with PP needs in mind
for ALS, EVA, EMC Systems, Science, Operations



Combined Areas of Importance for PP of Relevance to Lunar Architecture

Forward Contamination

- **Microbial Contamination Inside/Outside Habitat**
 - Understand Survival, Spread, Decay Rates Of Microbes
 - Current Vs. Prior Missions
 - Baseline Levels Of Contaminants Due To Human Presence
 - Track, Understand Microbes & Contaminants Near/Far Outside Habitat
 - Ingress/Egress Associated Contamination, Dusts Etc.
 - EVA & Suit Associated Contaminants (Characterize, Leak Rates, Etc.)
- **Operations**
 - Cleaning, Re-cleaning, Maintenance Of Tools, Suits, Habitat, Etc.
 - Waste Handling, Disposal & Venting From Habitat: Need to Understand, Control
 - Environmental Monitoring And Control (AEMC)
 - EVA, Habitats, Suits, Transit Vehicle Etc. Throughout Mission
 - ALS As Possible Contaminant Sources: Need understand
Biological Treatment Technologies, Bioregenerative Systems
 - Habitat Decontamination, Deactivation etc Upon Crew Departure (Microbial Concerns)



Combined Areas of Importance for PP with relevance to Lunar Architecture

Science Activities

- **Develop Technologies To Contain/Handle Samples On Planet**
- **Classification Of Outside Areas**
 - Based on Scientific Interest , Contamination Concern, Human Activities
 - Pre-mapping: Include Comm And Nav Systems Considerations
- **Improve Subsurface Sampling Technologies And Protocols**

ISRU Activities

- **Understand Contaminants & Possible Transfers**
(e.g., Food, Ice/Water, Life support systems, etc.)

Consider General Human Factors– Long Duration

- **Debilitation, Reduced Performance, Unintended Actions**
All With PP Implications
- **Onboard Crew-Member with Designated PP responsibilities**
- **Link PP With Ops, Flight And Medical Communities**

Science/Technology R&D

Determine

- ✓ **Survival of spacecraft associated terrestrial organisms & molecular components** in ambient Martian environment
- ✓ **Contamination Transport** (model near and far-field)
- ✓ **Quantitative & Qualitative life support system process streams** (air, water, wastes etc) for crew rated systems (e.g. habitat, EVA, suits etc)
- ✓ **Impact of PP Requirements on ISRU Operations and Systems**

Develop

- ✓ **Real-time monitoring system** for potential 'unknown' biology within pressurized volume
- ✓ **New Generation of suits, rovers, habitats, equipment** (clean, repair, decontaminate)
- ✓ **Sterilization and decontamination capabilities** for generated wastes, spacecraft volumes (habitat, EVA, suits etc.) and associated equipment and samples
- ✓ **Containment capabilities** for generated wastes, spacecraft volumes, associated equipment, samples and crew (quarantine)

In Addition.... Recent COSPAR action...

- In light of new knowledge about planetary bodies and the diversity and capabilities of terrestrial microorganisms in extreme environments, and increasing activities in space exploration, **it is recommended that COSPAR, working with the International Academy of Astronautics, the International Institute for Space Law, and other national and international institutions, seek the organization of an international workshop to consider whether biological planetary protection measures and other current practices intending to preserve planetary environments should be extended within a broader ethical and practical framework.**

Workshop topics should include:

- Ethical implications and responsibility to explore outer space in a manner that avoids harmful impacts on potential indigenous biospheres;
- Whether revision to current planetary protection policies are necessary to address these concerns, beyond the current protection of science to include further protections of planetary environments; and
- How best to involve the public in such a dialogue about the ethical aspects of planetary exploration.



Conclusions

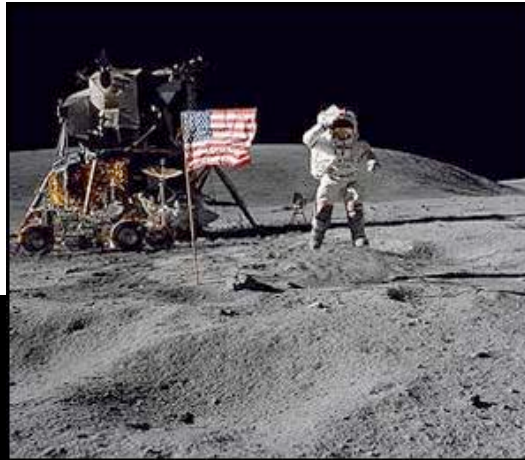
Addressing Scientific, Technical, Operational Aspects Of PP

- **Critical For Mars Human Missions**
- **Important Consideration For Lunar Missions**
 - **Enabling Technologies for Future Long Duration Planetary Missions**
 - **Use Moon As Test Bed**
 - **Avoid Two Distinct, Expensive Technology Pathways**
 - **Integrate into Early Planning and Designs**

Also Important To Communicate To Public about PP

- Explain PP Policy, Science and Technology As Part of Both Lunar And Mars Missions (Different from Apollo)
- Contribute To Public Understanding And Support For Missions
- Demonstrates Responsible Exploration

QUESTIONS?



Planetary Protection



All of the Planets, All of the Time....

